
MANGANESE

Characteristics

Manganese (Mn) is an element that can exist in several valence states: 1, 2, 3, 4, 6, or 7, the most common being +2, +3, and +7. Manganese may be found in over 100 minerals, primarily in the form of oxides, silicates, and carbonates. It is also found in coal and crude oil. Manganese is used primarily in making steel and non-ferrous alloys. Other uses for manganese and manganese compounds include the manufacturing of batteries, fertilizers, pesticides, and ceramics; as a gasoline additive; and as a dietary supplement. Manganese compounds are also used in animal feed, pharmaceutical products, wood preservatives, and as catalysts.

Natural emission sources of manganese to the atmosphere are the result of erosion of soils and dusts. Human activities that lead to the release of manganese and manganese compounds to air include industrial activities (such as alloy production and steel foundries) and combustion of fossil fuels (in power plants, coke ovens, and automobiles).

Manganese and manganese compounds exist in air associated with particulate matter, most of this particulate matter having a mass median equivalent less than 5 μm . The processes governing the fate of manganese in the atmosphere are the same processes as those that govern the transport and removal of particles from the atmosphere. The detection limit for ambient air monitoring (dichotomous sampling technique for particulate matter – 24-hour collection once every 6 days according to the predefined National Air Pollution Surveillance (NAPS) schedule) is $0.000021 \mu\text{g m}^{-3}$. From 1993 to 2003, the Edmonton Central air quality monitoring station (10225 104 St.) recorded 24-hour average manganese concentrations ranging from $0.00248 \mu\text{g m}^{-3}$ to $0.22570 \mu\text{g m}^{-3}$, with an average of $0.02206 \mu\text{g m}^{-3}$.

Effects

The adverse health effects of manganese are associated with inhalation of the inorganic form. Due to the lack of data, it is assumed manganese has similar levels of toxicity regardless of its oxidation state.

The primary end points of human toxicity associated with inhalation of inorganic manganese compounds related to particulate matter are neurotoxicity, reproductive dysfunction, and impairment of the respiratory system. Animal studies indicate that at concentrations from 3,900 to 69,000 $\mu\text{g m}^{-3}$ over exposure durations of 1 day to

18 weeks (on an intermittent basis); short-term exposures to manganese cause lung inflammation, difficulty breathing, increased susceptibility to pneumonia, and other respiratory effects.

Long-term inhalation exposure to manganese in the workplace is reported to cause: pneumonia, cough and decreased lung function, decreased neurobehavioural performance, weakness, anorexia, lack of muscle coordination, and decreased fertility in males. Most significantly are the neurological effects resulting from chronic manganese toxicity (manganism), which affects the central nervous system (CNS). Air concentrations of manganese oxide associated with these symptoms ranged from 27 to 3,600 $\mu\text{g m}^{-3}$ for exposure periods ranging from 1 to 35 years.

Objectives in Other Jurisdictions

The majority of the existing air quality objectives are derived from either the U.S. Environmental Protection Agency reference concentration (a chemical concentration to which humans can be exposed continuously for a lifetime without risk of ill effects) of 0.05 $\mu\text{g m}^{-3}$, or the American Conference of Governmental Industrial Hygienists Threshold Limit Value–Time Weighted Average of 5000 $\mu\text{g m}^{-3}$ (either of which are adjusted by the specific agency with various modifying and uncertainty factors). The US Agency for Toxic Substances and Disease Registry adopted a minimal risk level of 0.04 $\mu\text{g m}^{-3}$. The World Health Organization uses an ambient air guidance value of 0.15 $\mu\text{g m}^{-3}$ as an annual average. Agencies reviewed in the assessment report have set a variety of objectives: 2 to 119 $\mu\text{g m}^{-3}$ for 1-hour; 0.031 to 100 $\mu\text{g m}^{-3}$ for 24-hour; and 0.05 to 0.15 $\mu\text{g m}^{-3}$ for annual.

Alberta Ambient Air Quality Objectives

Alberta ambient air quality objectives are issued by Alberta Environment, under Section 14 (1), the *Environmental Protection and Enhancement Act, 1992* (EPEA). Based upon the available information, Alberta hereby adopts:

- From Texas, an Alberta Ambient Air Quality Objective for manganese of 2 $\mu\text{g m}^{-3}$ (0.89 ppb) as a 1-hour average concentration.
- From Texas and California, an Alberta Ambient Air Quality Objective for manganese of 0.2 $\mu\text{g m}^{-3}$ (0.089 ppb) as an annual average concentration.

Reference

WBK & Associates Inc., 2004: *Assessment Report on Manganese for Developing Ambient Air Quality Objectives*. Prepared for Alberta Environment. Edmonton, Alberta, Canada. 83 pp.